Digital Orthophoto Mosaic for
Roosevelt-Vanderbilt National Historic Site

Submitted to:
Beth Johnson, Inventory & Monitoring Coordinator
Northeast Region, National Park Service

Submitted by:
Center for Earth Observation, College of Natural Resources
North Carolina State University

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Aerial Photography Acquisition and Processing

On April 28, 2003, William Frament, USDA Forest Service (Northeastern Area State and Private Forestry, Durham, NH) acquired color infrared 1:8,000 scale aerial photography for a digital orthophoto mosaic of Roosevelt-Vanderbilt National Historic Site (ROVA); however, the photography was incomplete in that it only covered Vanderbilt Mansion. The following spring, on May 12, 2004, during leaf-on conditions, Frament acquired a complete set of aerial photography for the three properties that make up ROVA. Frament scanned the aerial photographs at 600 dpi and delivered the scanned image files, in TIFF format, and the hard copy photographs to North Carolina State University (NCSU). The aerial photographs, the camera calibration certificate, and a shapefile of the photo centers provided by Frament are stored in the archive that NCSU maintains for the NPS Northeast Region Inventory & Monitoring Program.

The mosaic was produced from 47 color infrared aerial photographs. Scanned .tif images of the aerial photographs were imported into ERDAS IMAGINE .img format where a photo block was created using a digital elevation model and digital orthophoto quarter quadrangles obtained from the U.S. Geological Survey (USGS) as reference. In preparation for this step, the digital elevation model was resampled from 30 meters to 10 meters and the digital orthophoto quarter quadrangles were mosaicked. The photo block was manipulated until it could be triangulated with a root mean square error of less than 1. Single frame orthophotos (one for each aerial photograph) were then generated and mosaicked using auto-cutlines in IMAGINE. Following computation of initial horizontal positional accuracy, the accuracy of the mosaic was improved by rectifying it with the digital orthophoto quarter quadrangle reference image using a second order polynomial with 16 ground control points. The resulting final mosaic was compressed using MrSID software with a 20:1 compression ratio. It is stored in the NCSU archive in both .img and MrSID formats.

Metadata

A metadata record for the mosaic was prepared in accordance with the current Federal Geographic Data Committee standards (FGDC 1998a). Metadata were produced in notepad and parsed using the USGS metadata compiler (USGS 2004). After all errors and omissions identified by the parser were corrected, the metadata compiler was used to generate final TXT, HTML, and XML versions of the metadata record which are stored in the NCSU archive. Key information for the mosaic is summarized in Table 1.

Positional Accuracy Assessment

The horizontal positional accuracy of the mosaic was assessed using guidelines of the USGS/NPS Vegetation Mapping Program (ESRI, NCGIA, and TNC 1994). Well-defined positional accuracy ground control points were placed throughout all quadrants of the mosaic in ArcMap. Ground control points and zoomed-in screenshots of each point were plotted on hard copy maps with the mosaic as a background. These maps and plots were used to locate the ground control points in the field. Field staff recorded the ground control point coordinates with a Trimble ProXRS GPS unit with real-time differential correction. Mapped ground control points that were physically inaccessible were also noted. The field crew collected accuracy assessment data at 37 ground control points. Prior to calculating accuracy, two ground control points were identified as outliers with SAS's JMP program and removed. The field-collected GPS coordinates for the remaining 35 points were compared to the coordinates obtained from the mosaic viewed in ArcMap. Both pairs of coordinates for each point were entered into a spreadsheet in order to calculate horizontal accuracy (in meters). The accuracy calculation formula is based on root mean square error (FGDC 1998b; Minnesota Governor's Council on Geographic Information and Minnesota Land Management Information Center 1999). Figure 1 shows the distribution of the ground control points within the park and surrounding area.

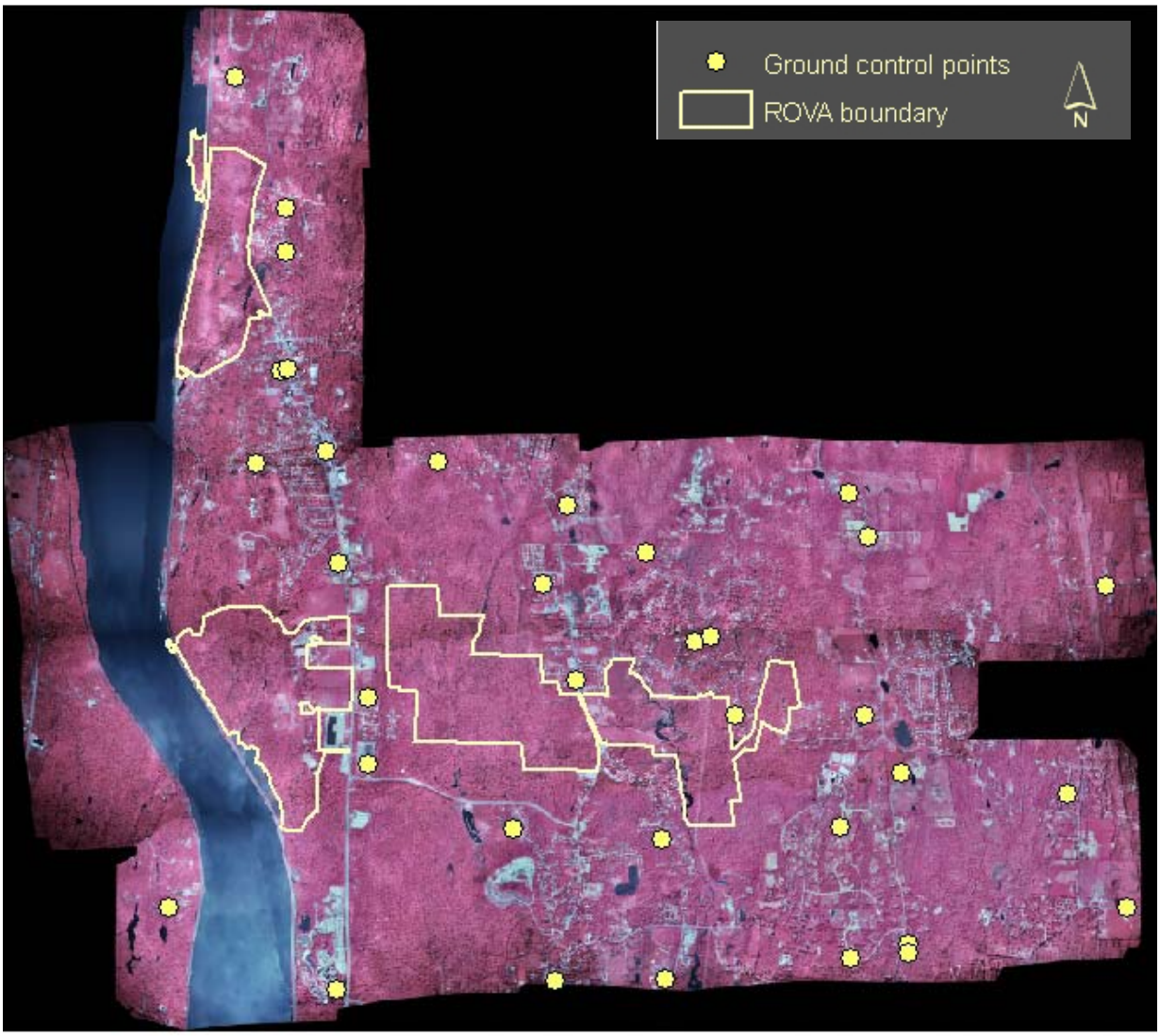
Positional Accuracy of Mosaic

The horizontal positional accuracy of the mosaic is 2.85 meters, which meets the Class 2 National Map Accuracy Standard (FGDC 1998b). A copy of the spreadsheet containing the x and y coordinates for each ground control point and the accuracy calculation formula is stored in the NCSU archive.

Table 1. Summary of key information for the Roosevelt-Vanderbilt National Historic Site mosaic.

Title of metadata record:	Roosevelt - Vanderbilt Mansion NHS Color Infrared Orthorectified Photomosaic – Leaf-on (ERDAS IMAGINE 8.7 .img and MrSID formats)
Publication date of mosaic (from metadata):	September 22, 2004
Date aerial photographs were acquired:	May 12, 2004
Vendor that provided aerial photographs:	William Frament, USDA Forest Service (Northeastern Area State and Private Forestry, Durham, NH)
Scale of aerial photographs:	1:8,000
Type of aerial photographs:	Color infrared, stereo pairs
Number of aerial photographs delivered:	47
Archive location of aerial photographs, camera calibration certificate, and shapefile of photo centers:	North Carolina State University, Center for Earth Observation
Scanning specifications:	600 dpi
Horizontal positional accuracy of mosaic:	2.85 meters, meets Class 2 National Map Accuracy Standard
Number of ground control points upon which estimated accuracy is based:	35
Method of calculating positional accuracy:	Root mean square error
Archive location of mosaic and metadata:	North Carolina State University, Center for Earth Observation
Formats of archived mosaic:	.img (uncompressed); MrSID (20:1 compression)

Figure 1. Ground control points used to calculate horizontal positional accuracy of the Roosevelt-Vanderbilt National Historic Site (ROVA) mosaic.



Literature Cited

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United States Geological Survey (USGS). November 1994. Standardized national vegetation classification system. USGS-NPS Vegetation Mapping Program. http://biology.usgs.gov/npsveg/classification/sect5.html (30 March 2006).

United States Geological Survey (USGS). 2004. Tools for creation of formal metadata, a compiler for formal metadata. Retrieved June 2004 from http://geology.usgs.gov/tools/metadata/tools/doc/mp.html

Scanning Specifications:

Aerial photographs for the National Parks listed below were scanned by William Frament, USDA Forest Service, Northeastern Area State and Private Forestry, Durham, NH (the individual who acquired the photography) at 800 dpi on a Microtek 9600 XL scanner.

Parks:

- BOHA
- MABI
- MIMA
- SAGA
- SAHI
- SARA
- ROVA

North Carolina State University
Center for Earth Observation
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United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Reston, Virginia 20192

REPORT OF CALIBRATION
of Aerial Mapping Camera

March 16, 2001

Camera type: Wild RC8
Lens type: Wild Universal Aviogon
Nominal focal length: 153 mm

Camera serial no.: 899
Lens serial no.: 371
Maximum aperture: f/5.6
Test aperture: f/5.6

Submitted by: Four Star Aviation
North Andover, Massachusetts

Reference: Four Star Aviation letter of authorization dated March 16, 2001.

These measurements were made on Kodak Micro-flat glass plates, 0.25 inch thick, with spectroscopic emulsion type 157-01 Panchromatic, developed in D-19 at 68° F for 3 minutes with continuous agitation. These photographic plates were exposed on a multicollimator camera calibrator using a white light source rated at approximately 5200K.

I. Calibrated Focal Length: 152.153 mm

II. Lens Distortion

Field angle in AA

Field angle:	7.5°	15°	22.7°	30°	35°	40°
Symmetric radial (um)	3	5	3	-2	-5	-1
Decentering (um)	0	0	1	2	3	4

RADIAL LENS DIST.

Symmetric radial distortion parameters	Decentering distortion parameters	Calibrated principal point
$K_0 = -0.1777 \times 10^{-3}$	$P_1 = -0.1122 \times 10^{-6}$	$x_p = 0.000$ mm
$K_1 = 0.3828 \times 10^{-7}$	$P_2 = 0.2153 \times 10^{-6}$	$y_p = -0.004$ mm
$K_2 = -0.1650 \times 10^{-11}$	$P_3 = 0.0000$	
$K_3 = 0.0000$	$P_4 = 0.0000$	
$K_4 = 0.0000$		

The values and parameters for Calibrated Focal Length (CFL), Symmetric Radial Distortion (K_0,K_1,K_2,K_3,K_4), Decentering Distortion (P_1,P_2,P_3,P_4), and Calibrated Principal Point [point of symmetry] (x_p,y_p) were determined through a least-squares Simultaneous Multiframe Analytical Calibration (SMAC) adjustment. The x and y-coordinate measurements utilized in the adjustment of the above parameters have a standard deviation (σ) of ±3 microns.

III. Lens Resolving Power in cycles/mm

Area-weighted average resolution: 58

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	80	67	95	80	95	48	14
Tangential lines	80	67	48	48	67	57	34

The resolving power is obtained by photographing a series of test bars and examining the resultant image with appropriate magnification to find the spatial frequency of the finest pattern in which the bars can be counted with reasonable confidence. The series of patterns has spatial frequencies from 5 to 268 cycles/mm in a geometric series having a ratio of the 4th root of 2. Radial lines are parallel to a radius from the center of the field, and tangential lines are perpendicular to a radius.

IV. Filter Parallelism

The two surfaces of the Wild 450 No. 3232, 500 No. 2716, 700 no. 2766 and AV2.2x No. 3074 filters accompanying this camera are within 10 seconds of being parallel. The 500 filter was used for the calibration.

V. Shutter Calibration

Indicated time (sec)	Rise time (μ sec)	Fall Time (μ sec)	½ width time (ms)	Nom. Speed (sec.)	Efficiency (%)
1/200	868	844	4.74	1/240	89
1/400	438	429	2.39	1/470	89
1/600	279	270	1.57	1/720	89
1/700	254	251	1.34	1/840	89

The effective exposure times were determined with the lens at aperture f/5.6. The method is considered accurate within 3 percent. The technique used is Method I described in American National Standard PH3.48-1972(R1978).

VI. Magazine Platen

The platen mounted in Wild RC8 film magazine No. 982 does not depart from a true plane by more than 13 um (0.0005 in).

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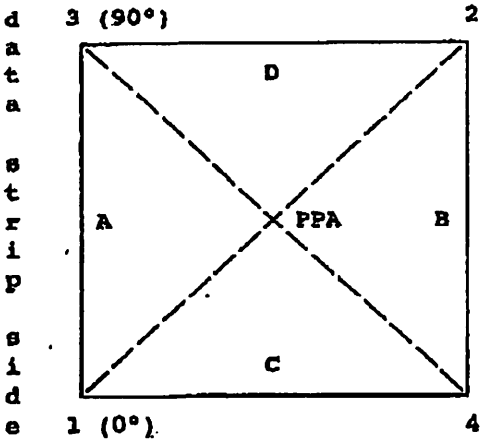
VII. Principal Points and Fiducial Coordinates



Positions of all points are referenced to the principal point of autocollimation (PPA) as origin. The diagram indicates the orientation of the reference points when the camera is viewed from the back, or a contact positive with the emulsion up. The data strip is to the left.

	X coordinate	Y coordinate
Indicated principal point, corner fiducials	-0.002 mm	0.042 mm
Principal point of autocollimation (PPA)	0.0	0.0
Calibrated principal point (pt. of sym.) x_p, y_p	0.000	-0.004

PRINCIPAL PTS

Fiducial Marks

1	-105.985 mm	-105.975 mm
2	106.070	106.147
3	-105.983	106.027
4	106.012	-105.975

FIDUCIALS

VIII. Distances Between Fiducial Marks

Corner fiducials (diagonals)

1-2: 299.938 mm 3-4: 299.811 mm

Lines joining these markers intersect at an angle of 89° 59' 25"

Corner fiducials (perimeter)

1-3: 212.002 mm 2-3: 211.998 mm

1-4: 212.053 mm 2-4: 212.122 mm

The method of measuring these distances is considered accurate within 0.003 mm

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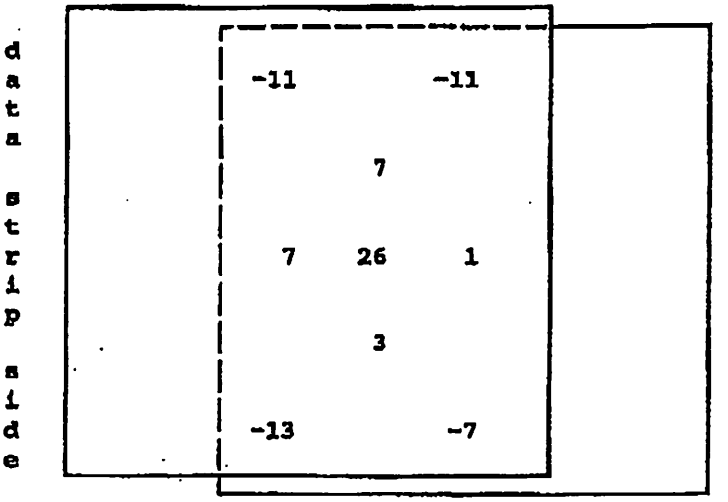
IX. Stereomodel Flatness

Magazine No.: 982

Base/Height ratio: 0.6

Maximum angle of field tested: 40°



Stereomodel
Test point array
(values in micrometers)

The values shown on the diagram are the average departures from flatness (at negative scale) for two computer-simulated stereo models. The values are based on comparator measurements on contact glass (Kodak Micro-flat) diapositives made from Kodak 2405 film exposures. These measurements can vary by as much as ± 5 μm from model to model.

X. System Resolving Power on film in cycles/mm

Area-weighted average resolution: 32 Film: Type 2405

Field angle:	0°	7.5°	15°	22.7°	30°	35°	40°
Radial Lines	40	34	48	40	48	34	14
Tangential lines	40	28	28	28	28	34	24

This aerial mapping camera calibration report supersedes the previously issued USGS Report No. OSL/2315, dated April 29, 1997.

John J. Lenart
Chief, Technology Operations Section
National Mapping Division